Analisis Parameter-Parameter Penting Neutronik Pada Reaktor Mikro Hidrid Indonesia

M. Yayan Adi Putra[1], Andang Widi Harto[1], Alexander Agung[1]

[1] Departemen Teknik Nuklir dan Teknik Fisika, Fakultas Teknik, Universitas Gadjah Mada, Jl. Grafika 2, Yogyakarta 55281, Indonesia

m.yayan.adi@ugm.ac.id

INTISARI

Mikro reaktor hidrid merupakan jenis reaktor nuklir berdaya kurang dari 10 MWe berbahan bakar uranium hidrid (UH_3) yang dikembangkan untuk keperluan sipil di wilayah 3T di Indonesia. Reaktor ini masih dalam tahap desain dasar. Dalam penelitian ini akan difokuskan pada optimalisasi pengayaan bahan bakar *low enriched uranium* (LEU) dan jumlah batang torium karbida (ThC) ditinjau dari aspek parameter neutronik seperti kritikalitas, reaktivitas pelepasan hidrogen, reaktivitas suhu, reaktivitas batang kendali, dan *burnup*. Pengayaan LEU divariasikan dari 11 % sampai 15 %, sedangkan jumlah batang ThC divariasikan dari 3 sampai 6 batang. Penelitian dilakukan dalam dua tahap : Studi Pendahuluan dan Studi Keselamatan Neutronik. Studi Pendahuluan dilakukan untuk mendapatkan konfigurasi pengayaan dan jumlah batang ThC optimal. Sedangkan Studi Keselamatan Neutronik dilakukkan untuk menguji lebih lanjut konfigurasi optimal seperti reaktivitas pelepasan hidrogen, koefisien reaktivitas suhu, dan reaktivitas batang kendali. Perhitungan analisis parameter neutronik menggunakan perangkat lunak Serpent 2.0 dengan pustaka tampang lintang ENDF/B-VII.0. Hasil analisis menunjukan bahwa pengayaan bahan bakar 13% dan jumlah batang ThC 6 batang dapat memenuhi persyaratan keselamatan melekat (*inherent safe*) serta dapat beroperasi 15 tahun lebih. Analisis keselamatan neutronik menunjukkan bahwa nilai reaktivitas pelepasan hidrogen pada suhu 300,15 K, 673,15 K, dan 973,15 K masing-masing dapat dirumuskan $\alpha_{HL300} = 1{,}0377 - 0{,}0026LH,$ $\alpha_{HL673} = 1{,}0290 - 0{,}0027LH,$ dan $\alpha_{HL973} = 1{,}0259 - 0{,}0028LH$. Nilai *temperature coefficient reactivity* (TCR) pada bahan bakar, pendingin, reflektor, dan total masing-masing dapat dirumuskan $\alpha_{FTC} = 3{,}2616 \times 10^{-2} - 1{,}6834 \times 10^{-5}T$, $\alpha_{CTC} = 1{,}9147 \times 10^{-2} - 1{,}4726 \times 10^{-6}T$, $\alpha_{RTC} = 1{,}8150 \times 10^{-2} + 4{,}7933 \times 10^{-7}T$, dan $\alpha_{TOT} = 3{,}3695 \times 10^{-2} - 1{,}6975 \times 10^{-5}T$. Nilai reaktivitas batang kendali grup 1, grup 2, atau kombinasi dua grup saat disisipkan dalam teras reaktor untuk suhu 300, 15 K dan 973, 15 K bernilai negatif. Dari hasil penelitian ini, desain reaktor mikro hidrid Indonesia menunjukkan bahwa reaktivitas pelepasan hidrogen, reaktivitas TCR, dan reaktivitas batang kendali bernilai negatif dan layak menjadi desain reaktor mikro yang memiliki karakteristik *inherent safe*.

Kata kunci: mikro reaktor, hidrid, torium, neutronik, optimalisasi, *inherent safe*

Analysis of Critical Neutronic Parameters of Indonesian Hydrided Microreactor

M. Yayan Adi Putra[1], Andang Widi Harto[1], Alexander Agung[1]

[1] Department of Nuclear Engineering and Physics Enginering, Faculty of Engineering, Universitas Gadjah Mada, Jl. Grafika 2, Yogyakarta 55281, Indonesia

m.yayan.adi@ugm.ac.id

ABSTRACT

Hydride microreactor is a type of nuclear power reactor with nominal power of less than 10 MWe fueled with uranium hydride (UH_3). This microreactor design is intended for civilian uses in frontier, outermost, and least developed (3T) area in Indonesia. This research will be focused on the optimization of its low-enriched uranium (LEU) fuel enrichment and the number of ThC rods acting as fertile fuel from the neutronic parameters, such as criticality, hydrogen release reactivity, temperature feedback reactivity, control rod reactivity, and burnup. LEU enrichment was varied from 11%wt to 15%wt, while ThC fuel rods were varied from 3 to 6 rods. This research was performed in two steps: Preliminary Study and Neutronic Safety Study. Preliminary Study was done to obtain the optimum LEU enrichment and number of ThC rods for the hydride microreactor. Meanwhile, Neutronic Safety Study was done to further analyze the optimum configurationn such as hydrgen release reactivity, temperature coefficient of reactivity (TCR), and control rod reactivity. Neutronic calculation was performed using Serpent-2.0 reactor physics code with ENDF/B-VII.0 neutron cross section. Analysis results show that 13% LEU enrichment and 6 ThC rods can allow the reactor to operate longer than 15 years and fulfilled neutronic safety criteria. Neutronic safety analysis shows that the hydrogen release reactivity in temperature of 300.15K, 673.15K, dan 973.15K can be formulated as $\alpha_{HL300} = 1.0377 - 0.0026LH,$ $\alpha_{HL673} = 1.0290 - 0.0027LH,$ and $\alpha_{HL973} = 1.0259 - 0.0028LH$, respectively. TCR in fuel, coolant, reflector, and sum of those components are formulated as $\alpha_{FTC} = 3.2616 \times 10^{-2} - 1.6834 \times 10^{-5}T$, $\alpha_{CTC} = 1.9147 \times 10^{-2} - 1.4726 \times 10^{-6}T$, $\alpha_{RTC} = 1.8150 \times 10^{-2} + 4.7933 \times 10^{-7}T$, and $\alpha_{TOT} = 3.3695 \times 10^{-2} - 1.6975 \times 10^{-5}T$, respectively. Control rod reactivity for group 1, group 2, and the combination of both for temperatures of 300.15K and 973.15K is negative. From the results, it can be understood that the Indonesian hydride microreactor has negative hydrogen release reactivity, TCR, and control rod reactivity. This design can be preliminary considered as feasible as a microreactor with inherently safe design.

Keywords : microreactor, hydride, thorium, neutronic, optimization, inherent safe